DEVICE FOR GENERATING MECHANICAL VIBRATION.

Field of the Invention

The invention presented concerns a device for generating mechanical vibration, intended primarily for dynamic compaction of various sorts of material.

Background of the Invention

For compacting various materials, e.g., in the construction of roads, airfields, vibratory compaction equipment is used to increase the compaction capacity and optimise the result of the compaction work.

Optimisation can consist, for example, of increasing the density of the material, increasing its bearing capacity, achieving a certain density profile with regard to depth and of obtaining a particular surface structure.

The equipment used can, for example, be rollers that have one or more vibrating drums, self-propelled vibratory plates, vibratory pokers and tampers.

To create the vibration, various types of mechanical systems having rotating eccentrics that utilise centrifugal force are used. This gives in space a rotating circular force vector and in time a sine shaped force vector in a certain direction.

To optimise compaction with regard to properties of the compacted material it is necessary that the vibration be given varying frequency, amplitude and direction.

Known vibratory devices with rotating eccentrics alter parameters of the force vector in the following way:

Examples of systems with one eccentric for achieving a circular force vector with variable amplitude:

~~See~~ checked US-patent 5,618,133 Vibrating mechanism and apparatus for generating ...
checked US-patent 4,342,523 High-low force amplitude device
checked US-patent 4,221,499 Vibratory device
checked US-patent 3,966,344 Adjustable vibratory roller

Amplitude of the vibration is changed in that the centre of mass for the eccentric weight is displaced in relation to the rotation centre of the eccentric.
The vibration frequency is set with the speed of rotation of the rotating eccentric.
This is achieved at present by some type of mechanical system.

Systems with two eccentrics:
Checked See US-patent 5,797,699 Process and apparatus for dynamic soil compaction.
A linear force vector is obtained by the two eccentrics rotating in different directions of rotation and fully synchronised, ie, at the same speed of rotation.
By phase displacement of the eccentrics so that the direction is changed as the eccentrics pass each other, the force vector can be controlled to act in varying directions.
Phase displacement of the eccentrics is made by a mechanical system.
Vibration frequency is set with the speed of rotation of the rotating eccentrics.

Characteristic for present vibration systems is that they only permit some specific form of vibration and that complicated mechanical devices are required.

A **Summary of the Invention**

The object of the invention presented is to optimise compaction with consideration to many different types of material being compacted using one and the same device.

Insert A2 ~~Figure 1 and 2 are schematic drawings of the device and figure 3 is a form of execution.~~

The invention is characterised thereby, in that the generation of vibration is made by a system 1 of two or more so-called force vector cells 2 and where a rotating eccentric 10 in each force vector cell generates a circular rotating force vector.
All force vector cells 2 generate a force vector that acts in the form of a resulting force vector on the common mass 3.
Each eccentric 10 is rotated by a separate electrically controlled drive 11, e.g., electric motor, hydraulic motor, and where the angular position of each eccentric in relation to a reference direction is measured by an angle sensor 12 with electric output signal 9.

Rotation of each eccentric with regard to rotation frequency, direction of rotation and phase position is controlled by a control and monitoring system 5 by a control signal 8 to the drive 11.

With control signal 6, a superior control device 4 determines signal 7, containing a rotation frequency, a direction of rotation and a phase position for each force vector cell 2 to achieve a determined resulting force vector diagram.
The control devices 4 and 5 are at present based on microcomputers for advanced control and monitoring and simple re-programming of the vibration characteristics.

By choosing a suitable number of eccentrics 10, centrifugal force of the eccentrics, frequency, direction of rotation and phase position, it is possible to generate a force vector diagram of suitable form, in space and time.

With one and the same configuration of force vector cells 2, many different types of force vector diagrams can be obtained.
The form of the resulting dynamic force vector diagram can easily be optimised with regard to factors such as the degree of compaction, direction of movement of the compacting appliance and the static force vector from the mass of the appliance.
The invention also allows the force vector diagram to be “modulated” by varying the speed of rotation and phase position of the eccentrics in time.
For the compacting of certain types of material, optimisation can be achieved since the vibration is composed of several different frequencies (multi-frequency vibration).
The invention described also allows an existing apparatus to be easily “re-programmed” to conform to force vector diagrams that have been tested and to new types of material that need to be compacted.

See figure 4–7 for some typical force vector diagrams that can be achieved:

Figure 4: Circular force vector diagram with adjustable amplitude:
The vibration system consists of two force vector cells, where the eccentrics rotate in the same direction and at the same rotational speed and where the phase difference can be regulated.
This results in a circular force vector with amplitude that is adjustable between 0 and maximum depending on the phase difference between the eccentrics.
The figure shows amplitude of the rotating force vector for the phase differences 0, 135 and 180°.

Figure 5: Force vector with adjustable direction and fixed amplitude,
The vibration system consists of two force vector cells, where the eccentrics rotate in opposite directions and at the same rotational speed and where their phase position can be regulated.
This results in a linear force vector that acts in one direction only (+/-) and at fixed amplitude. Direction of the force vector depends on when the centrifugal forces of both eccentrics interact in one direction for each revolution.
The figure shows how displacing the phase position 0, 90 and 45° in relation to the reference direction can turn the force vector.

Figure 6: Force vector with adjustable direction and fixed amplitude,
The vibration system consists of two force vector cells, where the eccentrics rotate in opposite directions and where eccentric 2 rotates at double the rotational speed compared to eccentric 1.
By giving eccentric 2 different phase positions a force vector diagram with different combinations of depth and surface effect can be obtained.

Figure 7A:
The vibration system consists of three force vector cells, where the eccentrics 1 and 3 rotate in the same direction and eccentric 2 in the opposite direction
Speed of rotation for eccentric 1 = 4 Hz, eccentric 2 = 8 Hz, eccentric 3 = 12 Hz.

Amplitude of eccentric 1 = 0.5, eccentric 2 = 0.41, eccentric 3 = 0.18.

With these settings a force vector that acts in depth for a short period is obtained. Changing the phase position of the eccentrics turns the direction.

Figure 7B:
The vibration system consists of three force vector cells, where the eccentrics 1 and 3 rotate in the same direction and eccentric 2 in the opposite direction.
Speed of rotation for eccentric 1 = 4 Hz, eccentric 2 = 8 Hz, eccentric 3 = 12 Hz.
Amplitude of eccentric 1 = 0.5, eccentric 2 = 0.5, eccentric 3 = 0.5.
With these settings a force vector is obtained that has combined surface and depth effect.
Changing the phase position of the eccentrics turns the direction.

The execution form according to figure 3 is a device with two force vector cells 2a, 2b, where the eccentrics have coaxial location. This implies that the outer eccentric 10a rotates round the inner eccentric 10b. This location means that the mass centre (centre of gravity) of the eccentrics has the same axis of rotation 17 and the same rotation plane 18, which is of significance for the resulting force vector for both of the eccentrics.
The axles 14a and 14b are carried by a number of bearings 16 so that they can rotate freely in relation to one another and to the holder 15.
The principle of coaxial located eccentrics can also be used for 3 or more eccentrics.
The cells are mounted on a common plate 3 the mass of which shall vibrate to compact the underlying material.
The eccentrics 10a, 10b rotate with the respective axle 14a and 14b, which are common for the respective electric motor 11a, 11b and respective angle sensor 12a, 12b.
The motor 11a, 11b is fed from the control device 5a, 5b by a voltage 8a, 8b that determines the direction and speed of rotation for the axle 14a, 14b.
From angle sensor 12a, 12b a signal 9a, 9b is given that is the angle value of the eccentric 10a, 10b in relation to a reference direction which, for example, can be in the horizontal plane.
The signal 7a, 7b from the control device 4 is the desired value for the direction of rotation, speed of rotation and phase position for the eccentric 10a, 10b.

From the signal 9a, 9b from the angle sensor 12a, 12b the control device 5a, 5b calculates the value of the real direction of rotation, speed of rotation and phase position for the eccentric 10a, 10b. Consequently, these values form the actual value of the control system.

The control device 5a, 5b regulates with the voltage 8a, 8b the electric motor 11a, 11b so that the desired value and the actual value are the same.

The signal 6 gives the parameters for the operational case to the control device 4. The parameters can for example be the frequencies for the vibration, form of the force vector diagram and modulation.